SD-1306
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Data Acquisition for Renewable Energy

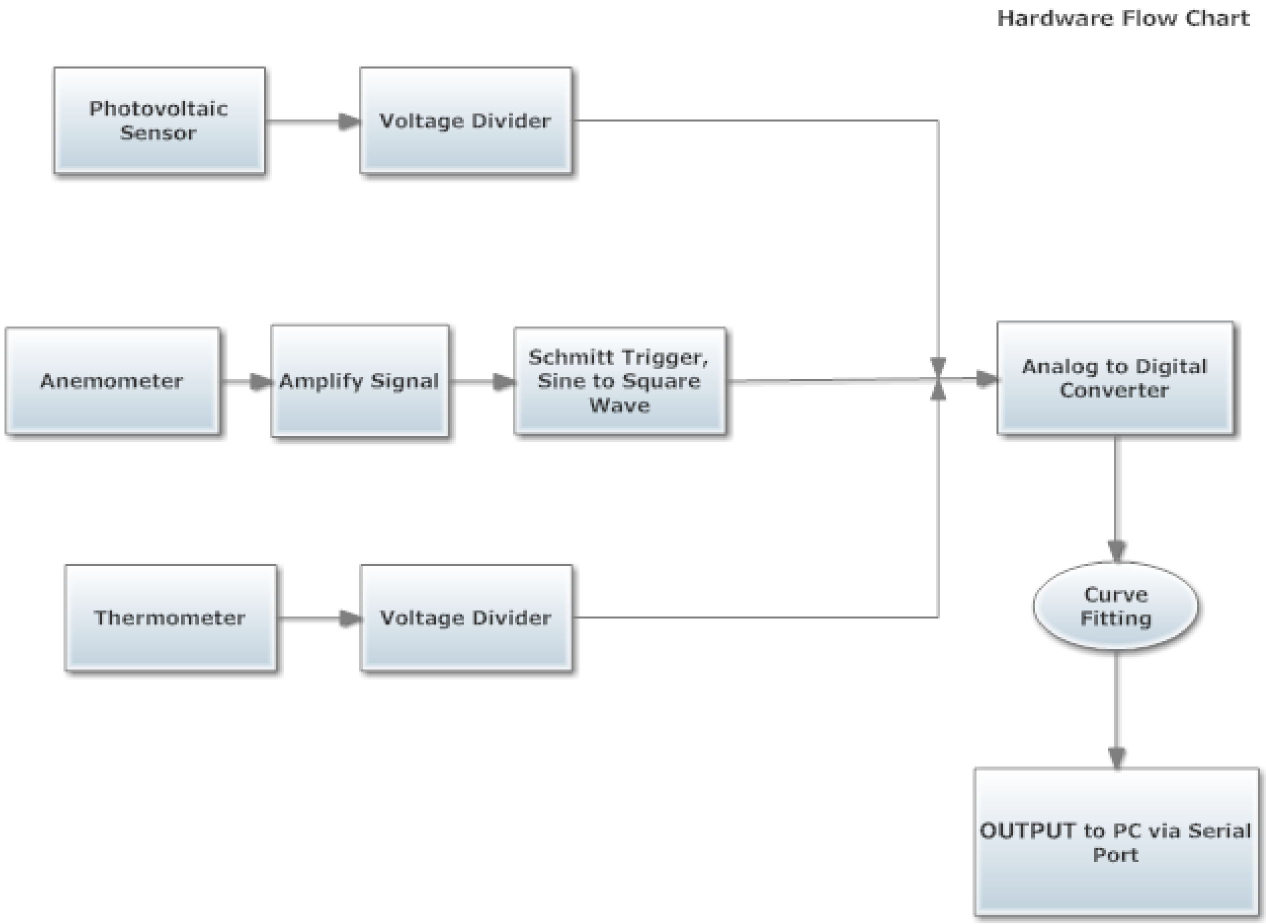
Introduction

- Our design project focuses on creating a device for acquisition of data pertaining to available solar and wind power in a remote location
- This data will be used to determine what type of renewable energy system would work best for the location
- We are focusing on measuring available energy from solar and wind
- Included in this presentation are our requirements, some technical and design information, our project status, our expenses so far, and our anticipated budget for remaining purchases.

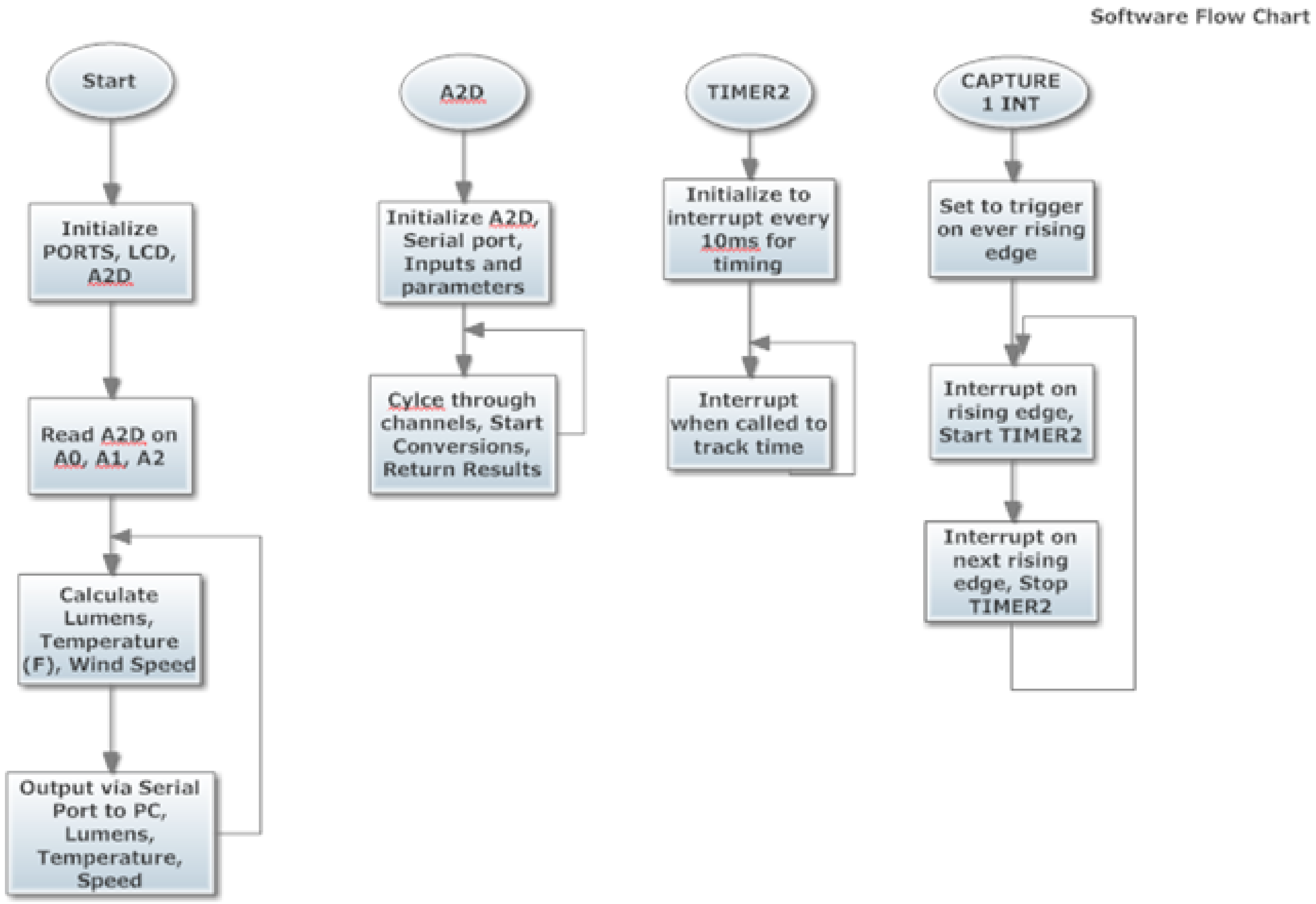
Requirements

- Needs to use an anemometer or similar device to measure wind speed
- Needs to use a calibrated photovoltaic cell or solar panel to measure solar energy
- Must be able to log and retrieve data from the system
- Must measure temperature to determine heating/cooling needs
- Must have enough memory to be able to store all data over an extended period of time
- Must be designed for minimal power consumption so the system can be relatively autonomous
- Components must be weatherproof and able to withstand outdoor exposure

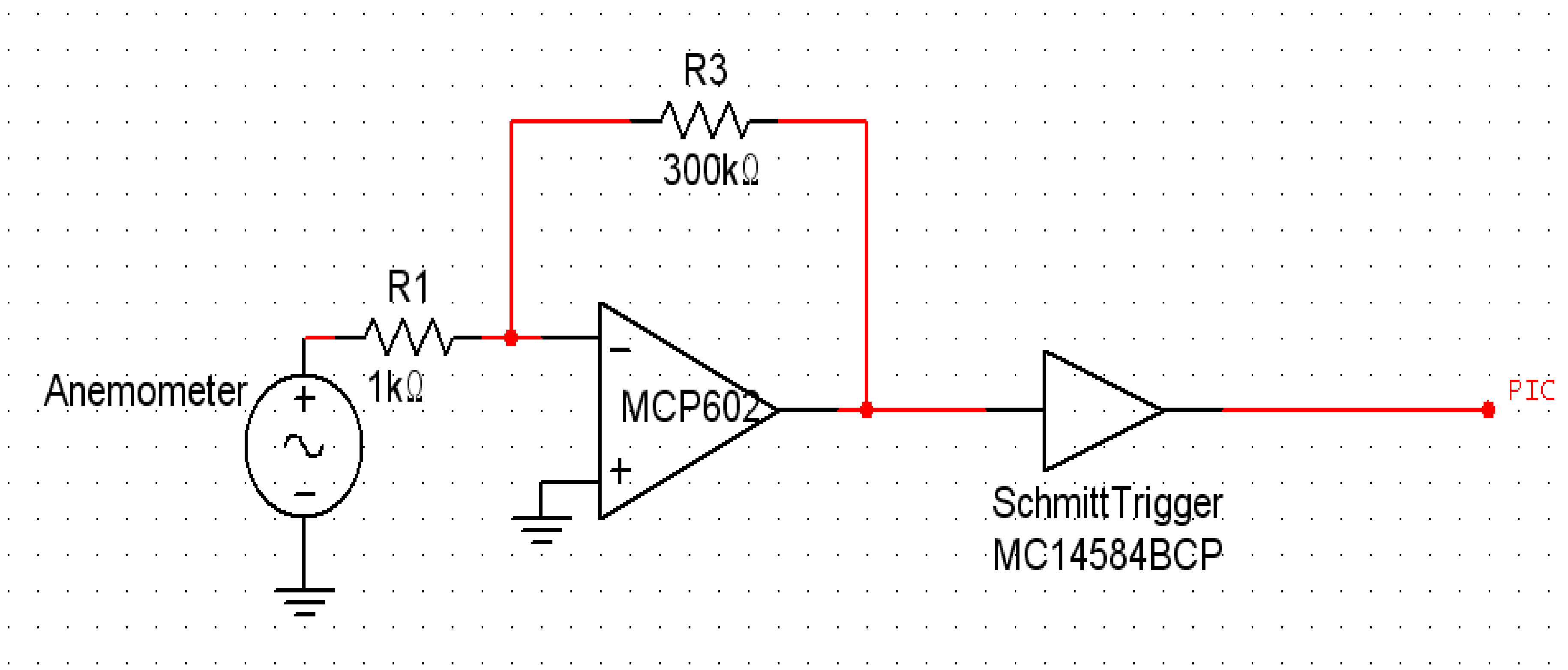
Hardware Flow Chart



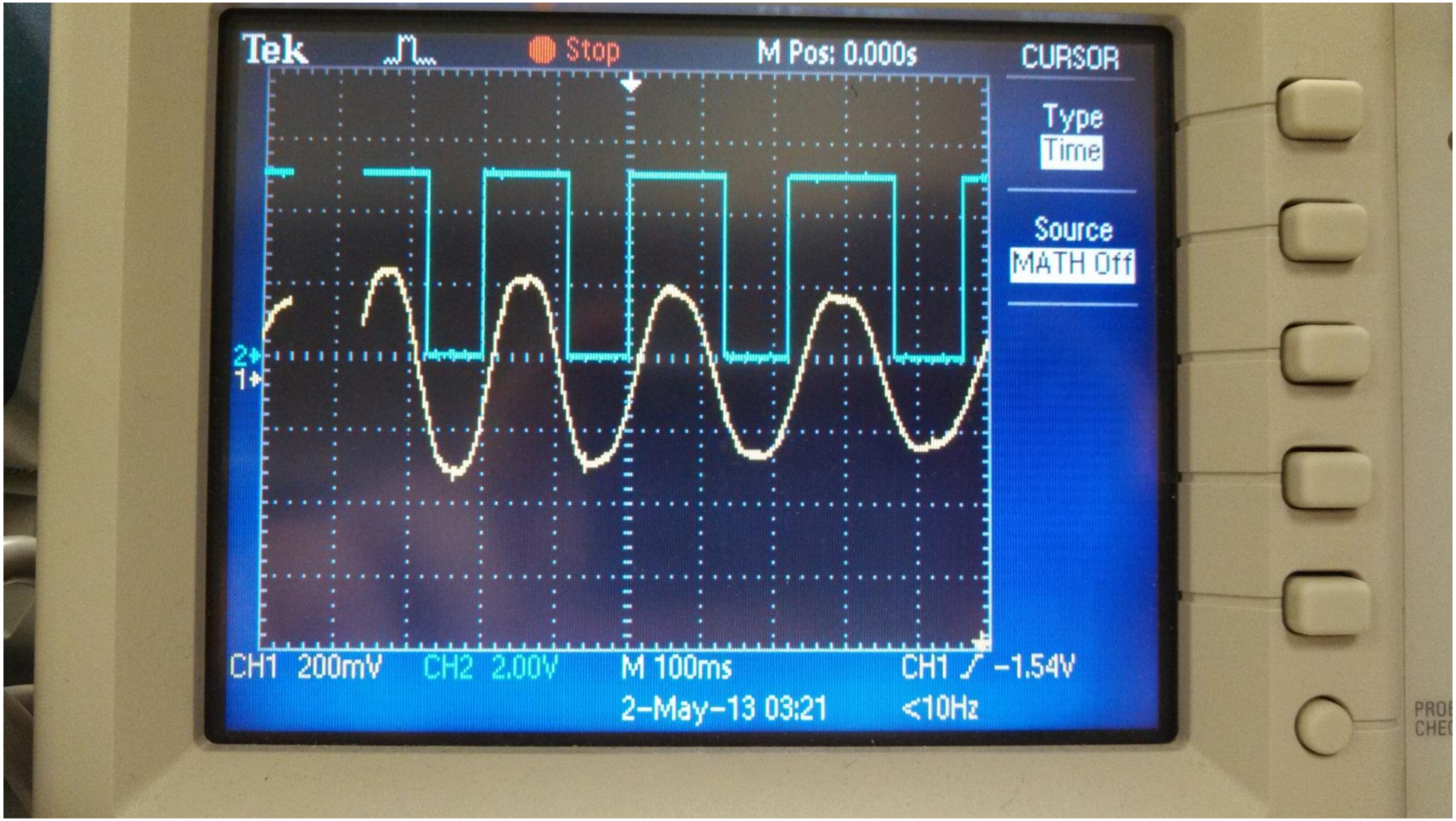
Software Flow Chart



Anemometer Sine-to-Square Wave Circuit Schematic



Input and Output of Anemometer Circuit



Calculation of Wind Velocity

- We are going to use a Capture Interrupt on the PIC to capture time at either a rising or falling edge of the square wave coming out of our circuit.
- We will calculate the period of the square wave by finding the difference between the time at a rising or falling edge and the time of the previous edge.
- From this, we can easily calculate frequency using the relationship:

$$\mathrm{f}\,[Hz] = \frac{1}{Period[sec]}$$

- Our anemometer is calibrated to have a transfer function for frequency to wind velocity of:

$$v\left[\frac{m}{s}\right] = 0.754f[Hz] + 0.44$$

- This function was derived from laboratory testing which is available online by looking up the serial number for our specific anemometer.
- Therefore, we can directly calculate the velocity from our determined period with the function:

$$v\left[\frac{m}{s}\right] = \frac{0.754}{Period[sec]} + 0.44$$

Calculating Available Power from Wind Energy

- The formula for the relationship between power available and wind velocity is:

$$P_{available} = \frac{1}{2}\rho A v^3 C_P$$

where

P: Power [Watts]
ρ: Air Density[kg/m^3]
A: Swept Area of Turbine [m^2]
v: Wind Velocity [m/s]
C_P: Betz Limit (turbine property)[max ≥ 0.59]

- To find wind energy, multiply available power times hours of turbine operation:

Energy [Watt-hours]=Power [Watts] * Time [Hours]

Solar Energy Information

- Our photovoltaic (PV) panel is a DC generator powered by the sun.
- When light photons of sufficient energy strike the PV panel, the silicon releases electrons.
- These electrons can be harnessed to produce an electric current.
- The electrons travel through an external circuit (battery or other load) and then return to the solar cell.
- The current produced by the PV panel is proportional to the irradiance, which is a measure of the sun's power available at the surface of the earth.
- We can measure the current and voltage coming from the PV panel to calculate the electrical energy potential from solar energy

Data Logging via Serial Port to PC

- We are currently able to log three different inputs of data using the PIC to a serial port on a PC
- We have included an example of our data, the first column is the sample number, the second is light intensity, the third is the temperature, and the fourth is the input from the anemometer (not fully calibrated yet)

Sample	Lumens	Temp(F)	Wind Speed
)001	034	073	130
002	146	071	130
003	145	073	130
004	143	071	130
005	126	071	130
006	098	071	130
007	085	078	130
008	121	078	130
009	126	077	130
010	130	077	130
011	130	077	130
012	132	075	130
013	136	075	130
014	135	075	130
015	135	075	130
016	135	075	130
017	134	075	130
018	132	073	130

Project Status

- We have all major parts for a prototype of our system, including an anemometer, temperature sensor, microcontroller, and solar panel.
- As of now, we have software written for the PIC that logs data to a PC via serial port.
- We can log data from three different inputs, which we will need to do to record temperature, wind, and solar data.
- We have a circuit breadboarded to convert our sine wave output of the anemometer to a square wave so that we can record the frequency of the signal, and from that, determine wind speed.
- We still need to refine our code so that it is optimized for our purposes, possibly modifying sampling rate or calibration of instruments.
- We need to determine the best method of storing our data, and how best to accomplish that, whether it is via USB flash drive, SD card, or some other method.
- Once our prototype is finished, we need to determine the best way to enclose our components to protect them against the elements

Updated Timeline

- Over the summer:
  - Continue to refine code for PIC and get all inputs reading simultaneously
- Next semester:
  - Week 1-3:
    - Analyze power consumption of system and make sure we have enough power to run system autonomously for an extended period of time with all components
    - Determining best way to store data in memory and modifying code for that purpose
    - Circuit PCB layout in Altium
  - Week 4-6:
    - Send PCB out for fabrication
    - Begin designing and fabricating necessary housing, weather-proofing of system, brackets and mounting, etc.
  - Week 7-9:
    - Soldering PCBs, circuit testing, system assembly
  - Week 10-12:
    - Preparing methods for data analysis once we know exactly what data values we are going to be measuring, possibly write a computer program to interpret our data into usable power information
  - Weeks 12-18:
    - Time for troubleshooting and revisions, dealing with any unanticipated issues that may arise
    - Testing complete system and dealing with problems
    - Preparation for Demo Day and Final Presentation

Updated Budget

ITEMS PURCHASED

- NRG #40C Calibrated anemometer ($290 retail, $40 acquired)
- PIC 18F4620 Microcontroller and Development Board ($85 retail, $0 acquired)
- Panasonic LC-R0612P1 (6V, 12Ah)Lead-Acid Battery ($30 retail, $17 acquired)
- Brunton Solarflat 6V Solar Panel ($25 retail, $25 acquired)
- DS1620 Temperature Sensor IC ($6 retail, $6 acquired)
- Total: about $88

REMAINING PURCHASES

- Enclosure ($80 estimated)
- Materials for mounting, wiring, conduit, fasteners ($50 estimated)
- Flash Drive or SD Card for data storage ($10 estimated)
- Total: about $140

Summary

- Overview
  - Requirements
  - Hardware & Software Flow Charts
  - Circuit Schematics
  - Oscilloscope Capture
  - Wind Energy Information
  - Solar Energy Information
  - Data Logging
  - Status and Timeline
  - Budget